Center Innovation Fund: LaRC CIF

Doped Chiral Polymer Negative Index Materials (DCPNIM)

Completed Technology Project (2012 - 2013)

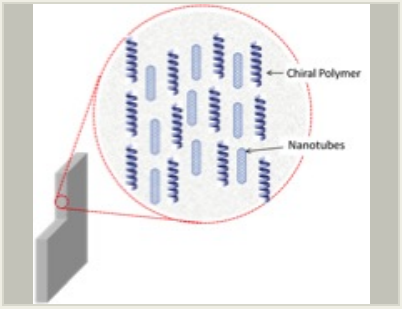
Project Introduction

Doped Chiral Polymer-Negative Index Materials (DCP-NIM) with tunable resonance frequencies are developed by adding various plasmonic nanoinclusions into chiral polymers. Amplifying the chiral parameter while lowering the real part of the permittivity can achieve an NIM metamaterial without having a negative permeability and a complex physical architecture. Novel lightweight, flexible DCP-NIMs can offer compact devices capable of dynamic beam steering, beam dispersion reduction, optical limiters.

Theoretical quantum chemical and electromagnetic (EM) modeling studies predict that materials with enhanced chiral parameter and suppressed permittivity create NIM without having a negative permeability [Opt. Exp. 15, 5730 (2007)]. Self-assembled helical structures of chiral molecules enhance the chiral parameters, while incorporating plasmonic inclusions, such as metal nanoparticles and nanotubes, efficiently lower the permittivity. The ratio of radius and pitch, polarizable moieties, and delocalized pi-electrons of the helical molecules influence the chiral parameter. Recent studies report that aligned liquid crystal polymers (LCPs) containing nano-inclusions create a new type of metamaterial whose index of refraction is tunable from negative to positive [Opt. Lett. 31, 2592 (2006)]. The resonance frequency can be tuned in a wide spectral range by controlling the refractive index of the LCP and the nature of the nano-inclusions. Recently, we have demonstrated negative permittivity materials by doping a non-chiral polymer with phosphoric acid or carbon nanotubes to obtain altered resonance frequencies ranging from kHz to GHz respectively. The resonance frequency can be tuned as a function of the dopant and the concentration [J. Appl. Poly. Sci. Early View]. By introducing aligned helical polymers with proper dopants or plasmonic nano-inclusions, novel lightweight, flexible NIM can be created with tunable resonance frequencies without complex physical architecture and negative permeability. The resonance frequency and magnitude of the NIM can be tailored for specific applications by judiciously selecting the chiral matrix and nano-inclusions. The resonance frequency of DCP-NIM can be further tuned by the composition, size, aspect ratio, and orientation (alignment) of these chiral matrix and nano-inclusions to cover a wide range of the EM spectrum from UV/Vis to infrared ranges, extended to microwave.

Anticipated Benefits

DCP-NIM with a tunable frequency offers compact devices capable of effective beam steering, beam dispersion reduction for laser/telescope, superlens, optical limiter, and other astronomical systems.



Project Image Doped Chiral Polymer Negative Index Materials (DCPNIM)

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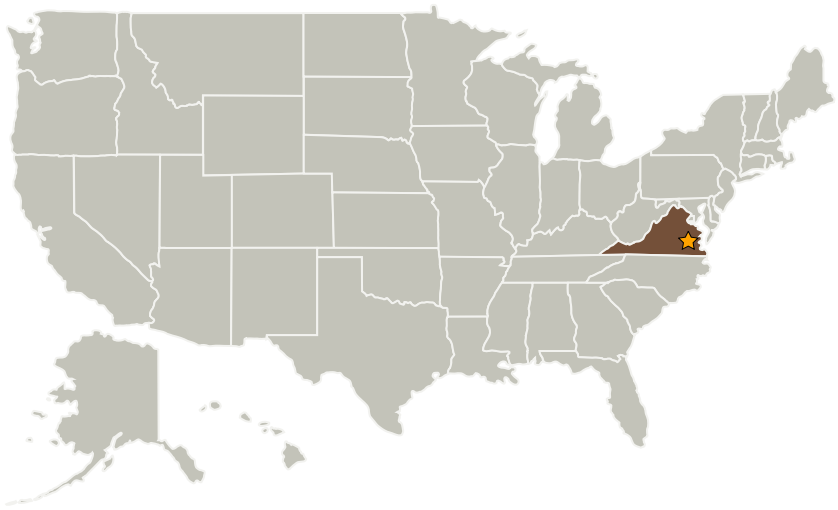
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia
National Institute of Aerospace	Supporting Organization	Academia	Hampton, Virginia

Primary U.S. Work Locations
Virginia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Center Innovation Fund: LaRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Julie A Williams-byrd

Project Manager:

Jeffrey A Herath

Principal Investigator:

Cheol Park

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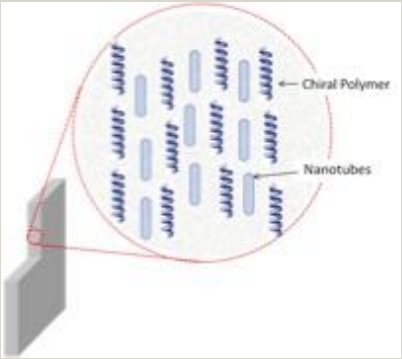
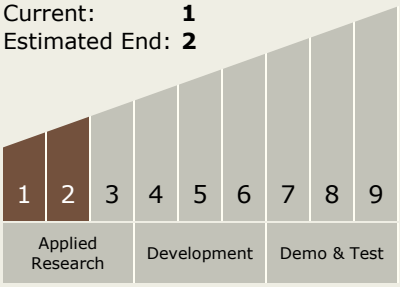
Images



28.jpg
Project Image Doped Chiral Polymer Negative Index Materials (DCPNIM)
(https://techport.nasa.gov/image/1257)

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.7 Special Materials